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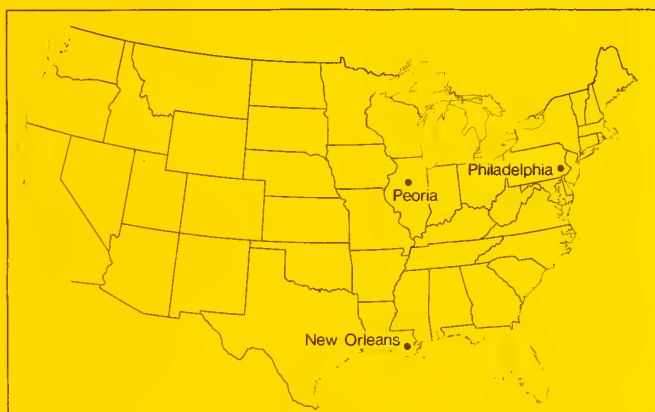
August 1987

# Agricultural Research on Industrial Uses for Fats and Oils

Finding new and broader uses for farm products has been part of the mission of the Agricultural Research Service (ARS) and its predecessors since the 1930's. Among farm products with the most potential for wider use are tallow (chiefly beef fat) and vegetable oils. Though both serve after some refining as food ingredients and as cooking fats and oils, these applications don't use all the available product.

Agricultural fats and oils are also excellent sources of industrial chemicals. Such chemicals include plasticizers, which add pliability to other substances; stabilizers, which help other substances resist chemical change; emulsifiers, which enable the mixing of normally unmixable liquids; surfactants, or surface-active agents, which reduce the surface tension of liquids and are commonly used in detergents; and esters and resins, both of which are basic ingredients in many products. Besides detergents and plastics, products that contain chemicals derived from fats and oils include lubricants, coatings, food and feed ingredients, corrosion inhibitors, adhesives, cleaners, cosmetics, water repellents, and fuels.

ARS research on industrial uses for fats and oils takes place mainly at the Northern Regional Research Center in Peoria, Illinois, the Eastern Regional Research Center in Philadelphia, Pennsylvania, and the Southern Regional Research Center in New Orleans, Louisiana. This publication summarizes some of the major ARS developments and ongoing research in industrial uses for fats and oils.



Locations where ARS carries out most of its research on industrial uses of fats and oils.

Because discussion of each development must be brief, many details have been omitted and technical aspects are often greatly simplified. For further technical information, write to:

Assistant Administrator  
Agricultural Research Service, USDA  
Room 358, Administration Building  
14th and Independence Ave., SW.  
Washington, DC 20250

Some of the processes and products described in this publication are patented. These are noted with the word "Patent." ARS now has the legal authority to issue exclusive patent licenses, depending on circumstances, at agency discretion. If you are interested in applying for a license on a patent or if you wish to receive a catalog listing all U.S. Department of Agriculture patents, write to:

Coordinator  
National Patent Program  
Agricultural Research Service, USDA  
Room 401, Bldg. 005  
Beltsville, MD 20705.

## Epoxidized Oils and Other Esters

During World War II, ARS scientists developed methods of treating fats and oils to produce epoxidized oils, which can be used as plasticizers and stabilizers. Epoxidized oils blend well with commonly used resins; don't evaporate; and minimize the need for such stabilizers as salts of lead, barium, and cadmium, which may be poisonous and also make plastics undesirably opaque. Over the past decade or so, commercial production of epoxidized ester plasticizers derived from fats and oils has been roughly 50,000 tons per year, with epoxidized soybean oil accounting for about 75 percent of total production.

## Polyamide Resins From Dimer and C<sub>21</sub> Dibasic Acids

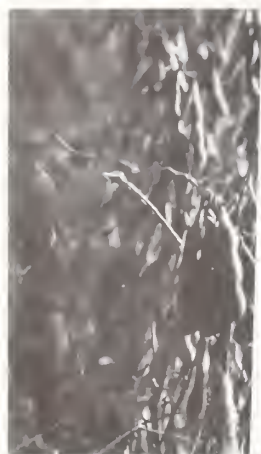
Research and development begun by ARS in the early 1940's led to commercial production and use of polyamide resins prepared from dimer acids that have been derived from soybean and other vegetable oils. Polyamides from dimer acids are used as hot-melt adhesives for shoe soles, book bindings, can-seam solders, and packaging. Because

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Developing new uses for surplus crops such as soybeans is the aim of much ARS research on fats and oils. (1176X1501-16)

they have flexibility, adhesion, and resistance to chemicals and moisture, they are used in flexigraphic inks and moisture-proof coatings. They are also used to make drip- and sag-resistant paints that don't need stirring and won't be absorbed into porous surfaces such as open-grained wood and cinder blocks. Widely used two-part adhesives (epoxy resins and polyamide curing agents) are also made from the polyamides developed from this research. U.S. production of dimer acids is roughly 30,000 tons per year; over half of this is used for polyamides.

Other sources of polyamides include  $C_{21}$  dibasic acids derived from the linoleic acid in, for example, soybean and cottonseed oils. Offering improved performance in many possible industrial applications,  $C_{21}$  dibasic acids and some of their derivatives can be used in ink resins, adhesives, permanent and temporary coatings for various products, corrosion inhibitors, lubricants, plasticizers, floor polishes, and all types of industrial and household cleaners.

### Sucrose Partial Esters

In 1969, ARS researchers developed a process that yields sucrose partial esters for food use and at the same time improves their potential for industrial uses. Earlier methods for producing them were more expensive and left undesirable constituents in the sucrose partial esters. The process developed by ARS works well with cottonseed oil and similar vegetable oils. This process has stimulated growth in commercial production of sucrose partial esters, especially in Japan. Since the ARS-invented process eliminates the need for dimethylformamide, some companies in the food industry may market them; they have other important potential uses. (Patent)

### h-Detergency Modified Soap

inary soap made from animal fats is an effective inser with a proven safety record and a rapid rate of degradation, but unmodified soap washes poorly in hard cold water. ARS scientists have modified soap by adding it with other fat-derived surfactants, called lime p-dispersing agents, to form new, highly effective isehold laundry detergents. These soap-based deter- its contain no phosphates; are nontoxic to humans, nestic animals, wildlife, and algae; and are completely d rapidly biodegradable (normal waste treatment and posal systems can easily digest them to harmless uent). The new detergents work well in hard, soft, cold, d hot water. They equaled or outperformed the most active household detergents on the U.S. market in various tests. (Patent)

### Cocoa Butter Substitutes

Cocoa butter, an important factor in the popularity of chocolate, is the world's most expensive food fat. The United States depends wholly on imports, largely from equatorial countries, and supply has long been influenced by climate and political conditions. After intensive studies on the properties of cocoa butter, ARS scientists developed a process to make a good cocoa butter substitute from a stearine that is a byproduct of the manufacture of salad oil from cottonseed oil. This stearine is a low-cost fat especially suitable for production of a cocoa butter substitute in a process that uses equipment already available in any cottonseed oil refinery. Similar studies led ARS researchers to a unique process for separation of tallow into three products of widely different physical properties. One of these products is a semisolid material ideally suited to be a cocoa butter substitute. (Patent)

### Isopropenyl Esters

ARS scientists have developed isopropenyl esters, a group of superior acylating agents—multipurpose chemicals—made from fatty acids. Isopropenyl esters could be used to give water repellency to such natural materials as paper and cotton, as components of glass coatings to reduce breakage in bottling lines, and in other applications where they have advantages over the commonly used acylating agents known as acyl halides. Most studied of the isopropenyl esters is IPS (isopropenyl stearate). The formation process yields IPS that is more than 90 percent pure. (Patents)



## Nylon 9

Nylon 9 is a plastic that can be made from oleic acid, a fatty acid found in most vegetable oils, including soybean oil. Because of its low moisture absorption, it doesn't warp and it's a better electrical insulator and poorer conductor than nylon 6, a commonly used and otherwise comparable plastic made from petrochemicals. Nylon 9 is also slightly stronger than nylon 11 and nylon 12, two plastics with similar properties. Because it can withstand high temperatures, nylon 9 would be an excellent material for making molded objects that will be subjected to large variations in air temperature—grills on automobiles, for example. Its low rate of moisture absorption makes it ideal for products that are electrically and water resistant—such as electrical parts and water pumps.

## Hydroformylation Products

ARS scientists have developed new, reusable catalysts to be used in the hydroformylation and hydrocarboxylation reactions. These processes can produce several useful chemical derivatives from fatty acids. The catalysts developed by ARS, particularly rhodium-triphenylphosphine, allow hydroformylation to occur at lower pressures and temperatures than are possible with the traditional catalyst. Yields are generally higher. Another catalyst developed by ARS, palladium chloride-triphenylphosphine, has similar advantages for the hydrocarboxylation reaction.



Technology developed by ARS to modify soap with lime soap-dispersing agents derived from fats is being used by manufacturers abroad in making laundry detergents, dishwashing liquids, and toilet soaps such as these produced in Japan. Use of ARS-developed processes by foreign industry often leads to expanded markets for U.S. agricultural surpluses. (PN-7249)

These catalytic processes have opened up new possibilities for use of fatty materials derived from vegetable oils, and many new compounds with commercial potential have been prepared. Some of these new compounds are sources of good plasticizers for vinyl plastics. Other potentially valuable applications include urethane coatings, polyamide resins, rigid urethane foams, a shrink-resistance treatment for wool, several types of coating resins, and lubricants, some suitable for jet engines. (Patents)

## Cyclic Fatty Acids From Vegetable Oils

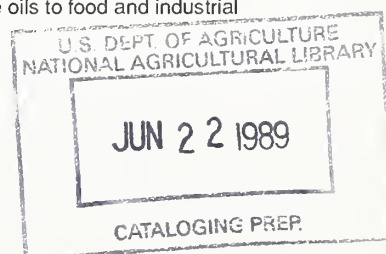
In the mid-1960's, ARS scientists investigated production of cyclic fatty acids from the linolenic acid in various vegetable oils, notably linseed oil, which comes from flax, and soybean soapstock (soy fatty acids that occur as a byproduct of a process used to make edible soybean oil products).

Various combinations of techniques and materials yielded five kinds of cyclic acids. One kind can be converted to a type of ester useful for high-performance lubricants. It can also be made into alcohols that have been tested in cosmetic formulations; these alcohols showed no skin toxicity and appeared to be more pleasing than cetyl alcohol, a common cosmetic ingredient.

The other four kinds of cyclic acid products may have applications where readily available natural fatty acids and their derivatives aren't the best choices for certain industrial



Modifying cottonseed oil with one of several methods ARS is testing for economical conversion of inexpensive vegetable oils to food and industrial uses. (0885X894-28)





Rates at which stainless steel balls fall through columns of representative fuels show relative viscosities. (0487X390-11)

uses. For example, a form of one of the soybean soapstock products is about as effective as erucamide as an antiblock agent for polyethylene film (to prevent sheets of film from sticking to each other). Erucamide is made from a type of rapeseed oil that must be imported. So use of a soybean-derived alternative would benefit U.S. agriculture, where soybeans are a surplus commodity.

## Vegetable Oils as Diesel Fuel

Vegetable oils have the potential to be reliably available substitutes for petroleum-derived diesel fuel. ARS studies have focused on resolving problems of high viscosity and low volatility—the chief reason seed oils can't yet be used for diesel fuel. Highly viscous oil clogs various mechanical parts of the engine or causes them to wear out faster because they have to work harder to force the oil to flow. Oil with low volatility doesn't combust completely, which means that it isn't efficient and also that it leaves residues that likewise contribute to engine clogging and abnormal wear. So far, researchers have been more successful at finding ways to lower the viscosity than they have been at increasing volatility.

Four approaches have been tried, with varying degrees of success—transesterification (conversion of one ester into another), dilution of vegetable oils with petroleum-derived diesel fuel, pyrolysis (using heat to break chemical bonds) of soybean oil, and microemulsification (making a stable homogeneous mixture from components that don't normally mix, like oil and water). Finding a way to more completely combust fuels containing vegetable oils would solve most of the remaining problems. To this end, research is continuing on fuel formulations, precombustion chemistry, combustion characteristics, and engine performance and endurance. (Patents)

## Outlook for the Future

ARS has renewed its commitment to research aimed at finding new nonfood uses of agricultural raw materials including fats and oils. This commitment is driven by the force of agricultural surpluses and is fueled with the opportunities afforded by new technologies. These include applications of microbial or enzyme engineering as well as novel chemical catalysts to carry out conversions that are not now possible or are too expensive by conventional processes to be economically competitive. Also being investigated are nontraditional means of product separation and recoveries to lower overall process costs. An objective of such research is to expand the market for fats and oils through innovative routes to specialty chemical products. Examples include products currently manufactured from imported oils such as coconut, tung, and castor oils. Discovery of economically competitive processes for converting fats and oils to shorter chain fatty acids, more highly unsaturated ones, or hydroxyacids would markedly broaden the spectrum of specialty chemicals that can be made from U.S. agricultural surpluses. Achievement of this objective should be expedited by cooperative research efforts with industry encouraged and facilitated by the Federal Technology Transfer Act of 1986 (Public Law 99-502).

The Agricultural Research Service is the principal research arm of the U.S. Department of Agriculture. Its mission is to find the most efficient and cost-effective methods for dealing with the problems facing U.S. agriculture. Research programs are planned and carried out in light of national priorities with the cooperation and advice of U.S. industry, State agricultural experiment stations and universities, and other organizations and institutions interested in the future of U.S. agriculture.





